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Equator, 1:80,000,000, or 1,262 statute miles to an inch. By Wilhelm Krebs. *Globus*, No. 11, Braunschweig, September, 1904.

The map indicates the position at sea from which seaquakes have been reported, the locations of submarine eruptions, and the places along coasts where earthquake and eruption waves have made themselves felt.

BOOK NOTICES.

Earthquakes in the Light of the New Seismology. By Clarence Edward Dutton, Major U.S.A. 314 pp. G. P. Putnam's Sons.

This volume is a reminder, hardly needed by the geologist, that Major Dutton was for many years a member of the U. S. Geological Survey, and is the author of the *Tertiary History of the Grand Canyon District, The High Plateaus of Utah, Hawaiian Volcanoes, and The Charleston Earthquake.* The present theme is too technical to allow much liberty of style, but one who has read the author's reports is not surprised to find a dash of eloquence on an early page in the general description of an earthquake.

The new seismology requires us to think of the earthquake, not as a cause, but rather as an effect, or incident of geological changes. We must also discard the notion of "earthquake weather," or other trustworthy signs of the coming of such disturbances. The cause of earthquakes is taken up early, and this discussion is followed by chapters on quakes of volcanic origin, and dislocation, or tectonic, quakes. The term "quake" is used throughout for the longer and more familiar word. Earthquakes by downthrow of parts of the earth's crust seem well verified; but the theory must not be carried too far, and does not, in the light of modern knowledge, require the existence of great subterranean cavities.

The association of quakes with volcanoes, in a casual way, is said to be as old as Aristotle. This is a valid principle, first really developed by Von Buch and Humboldt. The careful study of large numbers of modern quakes, however, shows that volcanic connections are absent in the greater number of cases, though a recognized cause in some. Volcanic quakes are not often felt at long distances from their point of origin, although they may be extremely violent about their epicentres. Thus in the earthquake of Casamicciola, on the island of Ischia, in 1883, 1,900 people were killed; while only a faint tremour was felt at Naples, but twenty-two miles away. The destructive shock connected with an eruption of Mount Ararat, in

1840, had a similar local character. Even Krakatoa, in one of the most violent eruptions on record, produced small vibrations at Batavia, only ninety miles distant, although it is well known that atmospheric and water waves were capable of detection in remote parts of the world. There is also, without doubt, much subterranean vulcanism, as in the intrusion of sheets and dikes, which is capable of producing seismic disturbances.

Tectonic quakes are due to dislocations of strata in great movements of the earth's crust. The well-known shocks in Chile, in 1822 and 1835, are cited as examples; also the New Zealand quake of 1855, as described by Lyell in the *Principles of Geology.* A more recent example occurred in Japan in October, 1891, where faulting was observed for a distance of seventy miles. Tectonic quakes, in distinction from volcanic, are followed by after-shocks of diminishing severity. The most "powerful and widespread" quake recorded in history took place in northeastern Bengal and Assam in 1897. The epicentral area was six thousand square miles in extent, and two hundred miles long, illustrating the further principle that in tectonic shocks the centre of disturbance is not well defined. In re-surveying, relative changes as great as twenty-five feet were found in the height of hills, and changes of twelve feet in horizontal distances.

The retreat of water, often occurring on sea borders, is freely attributed to sudden sinking of an area of sea-bottoms off shore, and an uprising is assumed in the rarer case in which the incoming wave first appears. Fresh evidence is cited regarding the Lisbon earthquake. It is from an eyewitness, in a pamphlet written soon after the event, and is noteworthy as making no reference to the widely-reported sinking of a quay, with the engulfing of a large number of people. The greatest amplitudes of earthquake waves are never recorded, since they are sufficient to wreck or overthrow the instruments, but they are known to reach at least a foot. This amplitude is attained only in soft ground, near the epicentre of a very violent movement. The amplitude in firm rock is probably never above two inches. The vertical amplitude is always less than the horizontal. It will not be without interest at the present time to note the large number of refined studies which our author cites as having been made by Japanese scholars.

The foci of volcanic quakes are especially shallow, but all quakes are characterized as "skin-deep." It is practically certain that no foci are so deep as thirty miles, and they are all probably within twenty miles of the surface.

The closing chapters of the book are mainly devoted to the more geographic aspects, of distribution and charting of the various regions of "seismicity." In determining the seismicity of a region both the frequency and the intensity are taken into account. Here the difficulty is in the fragmentary nature of the records in most parts of the world. M. De Montessus de Ballore is given credit for more extensive research in this field than all other seismologists combined, and his tables of distribution are republished as an appendix to this volume. The sources of knowledge are: historic narratives, not of scientific purpose, observations of sensible quakes without instruments, and seismographic observations, made with recording instruments. In a note on page 245 the author refers to the sensitiveness of the region about New Madrid, Mo., centre of the great shocks of 1811–12, and tells us it is doubtful whether the aftershocks have ceased even yet. This is, of course, a quake of the tectonic order, in which slips, with minor reliefs of strain, might continue for a long time.

It will surprise many readers to learn that Japan earthquakes do not tend to associate themselves with volcanoes. Most are tectonic and originate at sea, on the slope of sea-bottom that leads down to the Tuscarora Deep. Perhaps three per cent. of Japanese earthquakes are volcanic. The same is true of most Philippine disturbances. Japan and the Philippines are not, however, parts of a "fiery great circle," for there is no proof of exceptional seismicity between these two fields. Tectonic shakings originate in connection with the deeps near the Aleutian chain, and the California quakes suggest a tectonic origin. On the other hand, the Central American and South Mexican disturbances indicate volcanic origin, the interdependence of the two classes of phenomena being close and obvious. Both sorts of quakes are probably common, and intermingled along the Andes.

De Montessus de Ballore's deduction from distributions is that earthquakes occur where the variations of topographic relief are greatest—that is, along the great lines of corrugation of the earth's crust, either as they follow the lands, or sea-bottoms. Earthquakes are especially common in mountain regions and along the steepest flanks of mountains and on rapidly-deepening sea-bottoms. The quakes of Cuba and of neighbouring islands thus fall into relation with diversified and profoundly-submerged surfaces of that region.

A. P. B.